

INTRODUCTION

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NOMENCLATURE

C	=	Cohesive intercept: The component of soil shear strength which is independent of the force pushing the particles together.
E	=	Modulus of elasticity (psi)
GW	=	Ground water surface
I	=	Moment of inertial (in ⁴)
K _a	=	Lateral earth pressure coefficient for the active pressure condition
K _o	=	Lateral earth pressure coefficient for the at-rest condition
K _p	=	Lateral earth pressure coefficient for the passive pressure condition
K _w	=	Equivalent fluid soil pressure (pcf)
N	=	Standard penetration resistance
N _c	=	Bearing capacity factor
N ₀	=	Stability number
Q	=	Level surcharge loading (pcf)
q _u	=	Unconfined compressive strength (psf)
S	=	Section modulus (in ³)
SF	=	Safety factor
S _u	=	Undrained shear strength
α	=	Alpha - Angle from vertical to center of surcharge strip
β	=	Beta - Angle of soil slope
γ	=	Gamma - Unit Weight of soil (pcf)
δ	=	Delta - Wall friction angle
ϵ	=	Epsilon - Linear strain
θ	=	Theta - Angle of repose
μ	=	Mu - Angle of tieback with horizontal
ρ	=	Rho - Degree of flexibility Of an anchored bulkhead (Rowe's Moment Reduction theory)
σ	=	Sigma - Normal stress
Σ	=	Sigma - Sum
τ	=	Tau - Soil shear stress
ν	=	Upsilon - Poisson's ratio
ϕ	=	Phi - Angle of internal friction of soil
ψ	=	Psi - Failure wedge or slip angle
ω	=	Omega - Angle of the wall with respect to vertical

FHWA = Federal Highway Administration
Cal-OSHA = California Occupational Safety and Health Administration
Cal/OSHA = Cal-OSHA
AREA = American Railway Engineering Association

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PREFACE

The California Department of Transportation Trenching & Shoring Manual was originally developed by the Office of Structure Construction in 1977. Its purpose was to provide technical guidance for Structure's field engineers analyzing designs of trenching & shoring systems used in the California Highway Construction program.

This 1990 updated manual edition continues to be devoted to the analysis of trench and excavation earth support (shoring) systems. Its main objectives are to inform the Engineer of California's legal requirements, and to provide updated technical guidance for analysis and review.

The Engineer should bear in mind that this manual is a book of reference and instruction to be used in respect to the administration and engineering of excavation shoring. In cases of conflict, the contract documents shall prevail.

Current concepts in soil mechanics or geotechnical engineering are summarized in order to better acquaint the reader with the practical considerations and accepted application of theoretical principles. Situations or conditions which may cause difficulty are noted. A section on earth tiebacks has been added to this 1990 edition.

The engineering objective of a shoring systems is to be both safe and practical. There are two major parts of the engineering effort. First is the classification of the soil to be supported, determination of strength, calculation of lateral loads, and distribution of lateral pressures. This is the soil mechanics or geotechnical engineering effort. Second is the structural design or analysis of members comprising the shoring system. The first part, the practical application of soil mechanics, is the more difficult. The behavior and interaction of soils with earth support systems is a complex and often controversial subject. "Experts", books, and papers do not always concur even on basic theory or assumptions. Consequently, there are no absolute answers or exact numerical solutions. A flexible, yet conservative approach, is justified. This manual presents a procedure that will be adequate for most situations.

A portion of the text is devoted to the legal requirements and the responsibilities of the various parties involved. Construction personnel must be aware of the various legal requirements. Special restrictions are noted for excavations or trenches adjacent to railroads. A discussion on manufactured products is included.

There are many texts and publications of value other than those listed in the list of references. Use them; however, be cautious with older material. There are other satisfactory methods of approaching the engineering problem. The subject is recognized as an engineering art. The need for good judgment cannot be over

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emphasized. Do not lose sight of the primary objective: a safe and practical means of doing the work.

There are two major reasons why the Department considers shoring and earth retaining systems a subject apart from other temporary works such as falsework. First, an accident in a trench or excavation is more likely to have a greater potential for the maximum penalty, that is, the death of a workman. Cave-ins or shoring failures can happen suddenly, with little or no warning and with little opportunity for workers to take evasive action. Second, earth support systems design involves the complex interaction of soil types plus engineering factors that at best are controversial and highly empirical.

Trenching or shoring is generally considered temporary work. Temporary work can mean 90 days for complicated structures, but it can also be understood to mean only several days for much trenching work. The term "temporary" can be adversely affected by weather, material delays, change order work, strikes and labor disputes, and even subcontractor insolvency.

In preparing this manual through the year 1990 it has been the editors goal to cover as completely as practical some temporary earth retaining structures or systems. This manual is the result of consolidating the Office of Structure Construction experience and continued research and study by the Engineering staff. The initial edition of 1977 was well received by both the Department and the construction industry, and was distributed nationwide and to many foreign countries.

It would be impossible to acknowledge each and every individual who contributed to the development of the manual. However, recognition is due to the major contributors as follows:

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CALIFORNIA TRENCHING AND SHORING MANUAL

Cartoons by, and included as a dedication to, G. W. Thomson.

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This manual is available to the public. Checks should be made payable to the DEPARTMENT OF TRANSPORTATION.

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